



# Researchers explore correlation between climate and wildfires in the Southwest

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Two papers published by Los Alamos researchers in Earth System Observations (EES-14) and collaborators describe the conditions leading up to the catastrophic Las Conchas Fire and contemporaneous fires across the southwestern United States in 2011, as well as the overall trend of fire in the American Southwest and its relationship to atmospheric moisture. One paper was published in the *Journal of Applied Meteorology and Climatology* and the other in *International Journal of Wildland Fire*. The authors show that the annual forest fire area is very strongly dictated by drought. In turn, drought and subsequent wildfires are strongly influenced by the atmosphere's demand for moisture, which is a measure of the potential evaporation and transpiration that would occur if a sufficient water source is available. This atmospheric demand for moisture is strongly dictated by spring and summer temperatures; substantial warming during these seasons throughout the Southwest has caused the atmosphere's moisture demand to grow substantially in recent decades.

## Significance of the research

According to climate models, such as the Coupled Model Intercomparison Project (CMIP5), the Southwestern atmosphere should not be able to become as dry as it did in 2011. The research team concludes that the causes of the dry air in 2011 were most likely natural in origin, driven by an interaction of atmospheric, oceanic, and land surface conditions. However, 2011 should serve as a warning of what the climate is capable of in the Southwest. The year 2011 provided a glimpse at how wildfires might behave in the future, when warmth causes atmospheric moisture demand in an average year to reach 2011 levels. Modeling projects suggest that in a warmer future, if another anomalous event occurs where 2011-type atmospheric dynamics cause extremely low atmospheric water vapor content, the effects of this would be superimposed upon the effects of background warmth. The result would cause the atmospheric moisture demand to be unprecedentedly extreme and might cause catastrophic wildfire consequences if the amount of fuels is not limiting.

The effect of warming on forest fires in the Southwest is extreme due to a combination of exponential relationships. 1) Temperature has an exponential influence on atmospheric moisture demand, meaning that the effect of temperature variations on drought are strongest in places that are already relatively warm, and the effect gets even stronger as warming occurs. 2) The relationship between atmospheric moisture demand and burned area is exponential, meaning that even if the atmosphere's

moisture demand were to grow steadily, the annual area of forest fires would continue to grow exponentially. Continued warming in the Southwest could cause ever-growing burned-area totals in Southwestern forests until annual burned areas decline due to the limitation of fragmented forested areas that provide fuels.

The findings provide new understanding regarding the nature and strength of the relationships between Southwest wildfire and climate, with implications for seasonal burned area forecasting and future climate-induced wildfire trends. Observed wildfire-climate relationships in the already warm and dry Southwest may provide valuable insight relevant to other regions where the climate is likely to become substantially warmer and drier.

### **About the two research papers**

The paper published in the [\*Journal of Applied Meteorology and Climatology\*](#), examines the extreme 2011 drought in the Southwest. Droughts are typically caused when the atmosphere's demand for moisture (in the form of precipitation and potential evaporation) is greater than its supply; 2011 was the perfect example of the influence of this atmospheric moisture demand on wildfires. Although temperature usually dictates whether the atmosphere's moisture demand is high or low, the amount of water vapor in the air is also important. In spring and early summer of 2011, exceptionally low atmospheric moisture content combined with fairly warm air to result in record high total burned area in the Southwest.

The companion paper, published in the [\*International Journal of Wildland Fire\*](#), assesses the correlation between components of water balance and burned areas. The researchers used 30 years (1984-2013) of satellite observations to quantify recent trends, inter-annual variability, and burn severity in the burned area of the Southwest. During the time span, 11 percent (approximately 5,500 square miles) of Southwestern U.S. forest burned in wildfires, and over half of this area has burned since 2006. Over half of the forested area (approximately 3,200 square miles) has burned in stand-replacing wildfires in which most or the entire living upper canopy layer is killed. The annual area of these stand-replacing fires has grown exponentially since 1984, at a rate greater than 16 percent per year. The rate of growth is highest in high elevation forests, at a rate greater than 22 percent per year.

The research team

Former Lab postdoctoral fellow A. Park Williams, now of Columbia University, led the studies. Researchers include Richard Seager of Columbia University, Max Berkelhammer, Thomas Swetnam, and David Noone of University of Colorado – Boulder; Alison Macalady and Michael Crimmins of University of Arizona; Anna Trugman of Princeton University; Nikalous Buenning of University of Southern California; Natalia Hryniw of University of Washington; Nate McDowell, Claudia Mora, and Thom Rahn of Earth System Observations (EES-14).

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